Assessing Potential Health Impacts of Ozone & $PM_{2.5}$ Under a Changing Climate

Kim Knowlton[1], Michelle L Bell[2], Christian Hogrefe[3], Cynthia Rosenzweig[4], Patrick L Kinney[1]

[1]Columbia University, Mailman School of Public Health, NY, NY; [2]Yale University, School of Forestry & Environmental Studies, New Haven, CT; [3]Atmospheric Sciences Research Center, State University of New York, Albany, NY; [4]NASA-Goddard Institute for Space Studies, NY, NY

New York Climate & Health Project

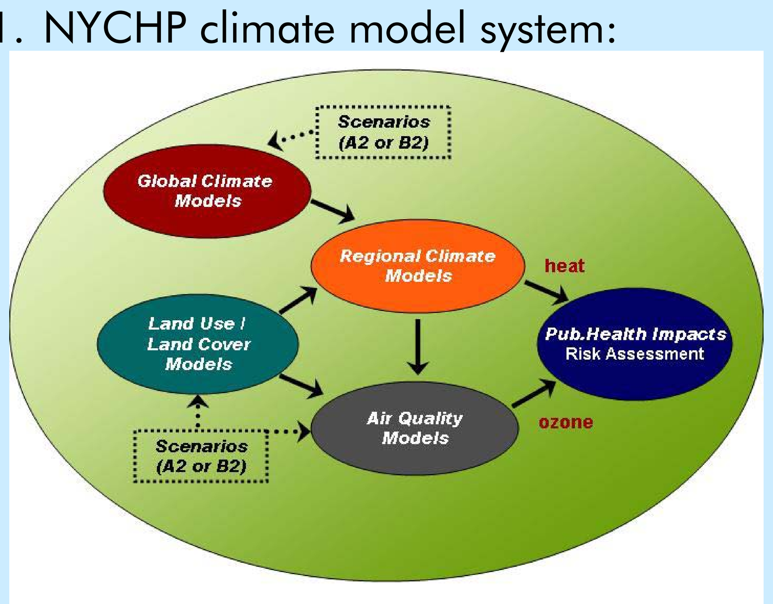
This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant # R828733

Introduction

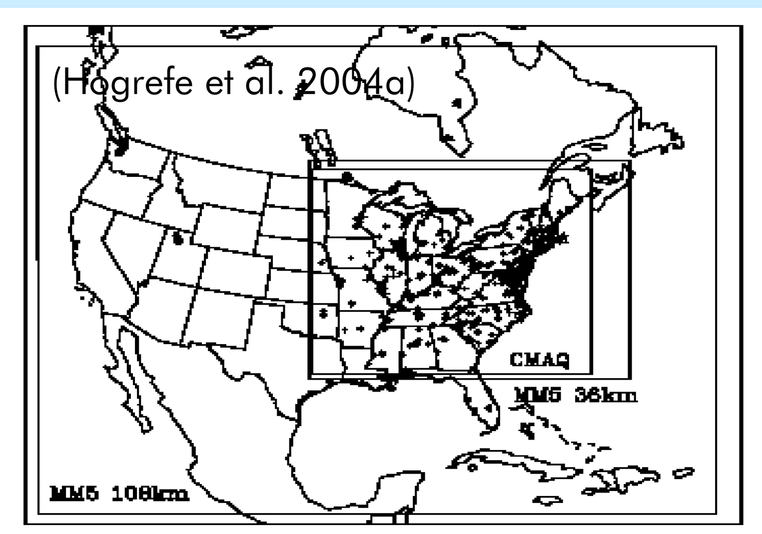
- Potential impacts of climate change on heat-related illness and death have received considerable attention, yet less is known about climate-related changes in air quality and corresponding health effects (Kinney et al. in review; Knowlton et al. 2004; Holloway et al. 2004).
- To address this need, the New York Climate & Health Project (NYCHP) developed a modeling framework to generate downscaled county-level estimates of ozone and $PM_{2.5}$ air quality under a changing climate and project human health impacts.

Methods 1

1. NYCHP climate model system:



- GISS coupled global ocean/atmosphere model driven by IPCC SRES scenarios (A2 & B2)
- MM5 regional climate model takes initial and boundary conditions from GISS GCM (Lynn et al. in review)



- MM5 run on 2 nested domains of 108 km and 36 km over eastern US, for 5 mid-decadal summers, 2050s vs. 1990s
- Using GCM-MM5 fields as input, CMAQ (Community Multiscale Air Quality) model simulated hourly surface ozone and PM $_{2.5}$ concentrations on a 36 km grid

Methods 2

2. CMAQ-simulated summer seasonal conditions (June–August) for five consecutive mid-decadal years (e.g., 1993-1997) in the 1990s vs.2050s
- Emissions of ozone precursors held constant at 1996 NET levels
- Estimated concentrations of daily average $PM_{2.5}$ include total sulfate, nitrate, ammonium, organic carbon, elemental carbon and crustal material

Methods 3: Health impacts

3. Evaluated from 36-km interpolated CMAQ fields via a county-level health risk assessment:

Study Population x Base Rate Health Impact x Change in Environment x Exposure-Risk Coefficient (ERC) = Number of Additional Deaths

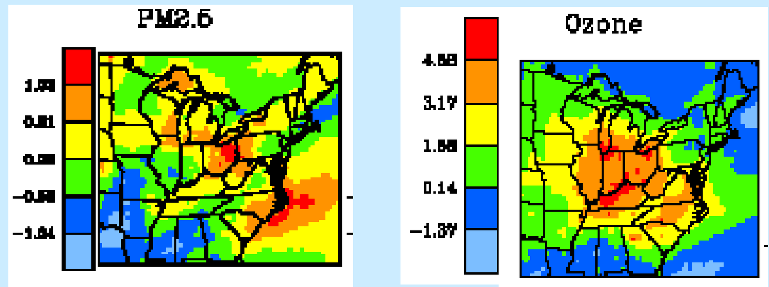
4. Exposure-risk coefficients (ERCs) from epidemiological literature applied:
- Mortality RR 1.0087 (1.0055, 1.0118) per 10 ppb increase in daily O_3, from Bell et al. (2005) meta-analysis of 39 O_3-mortality time series studies
- Mortality RR 1.06 (1.02-1.11) per 10 µg/m3 increase in long-term $PM_{2.5}$ exposure, from Pope et al. (2002)

5. Assume regional population constant at Census 2000 levels

Results

Regional mean summer O_3 & $PM_{2.5}$	1990s	2050s A2	2050s B2
O_3 simulated concentration, summer daily 1-hr max (ppb)	56.39	58.53	59.95
$PM_{2.5}$ simulated concentration, summer daily mean (ug/m^3)	14.9	14.6	*(n/a)*

- Slight decrease in total $PM_{2.5}$ over the 31-county study area by 2050s; domain-wide, slight increase in total $PM_{2.5}$ and larger summer O_3 increase by the 2050s (Hogrefe et al. 2005)



- Higher temperatures may favor more SO_2 conversion to sulfate, but some volatile nitrates and organic carbon aerosols transition back into gas phase as temperatures rise (Hogrefe et al. 2005)

Conclusions

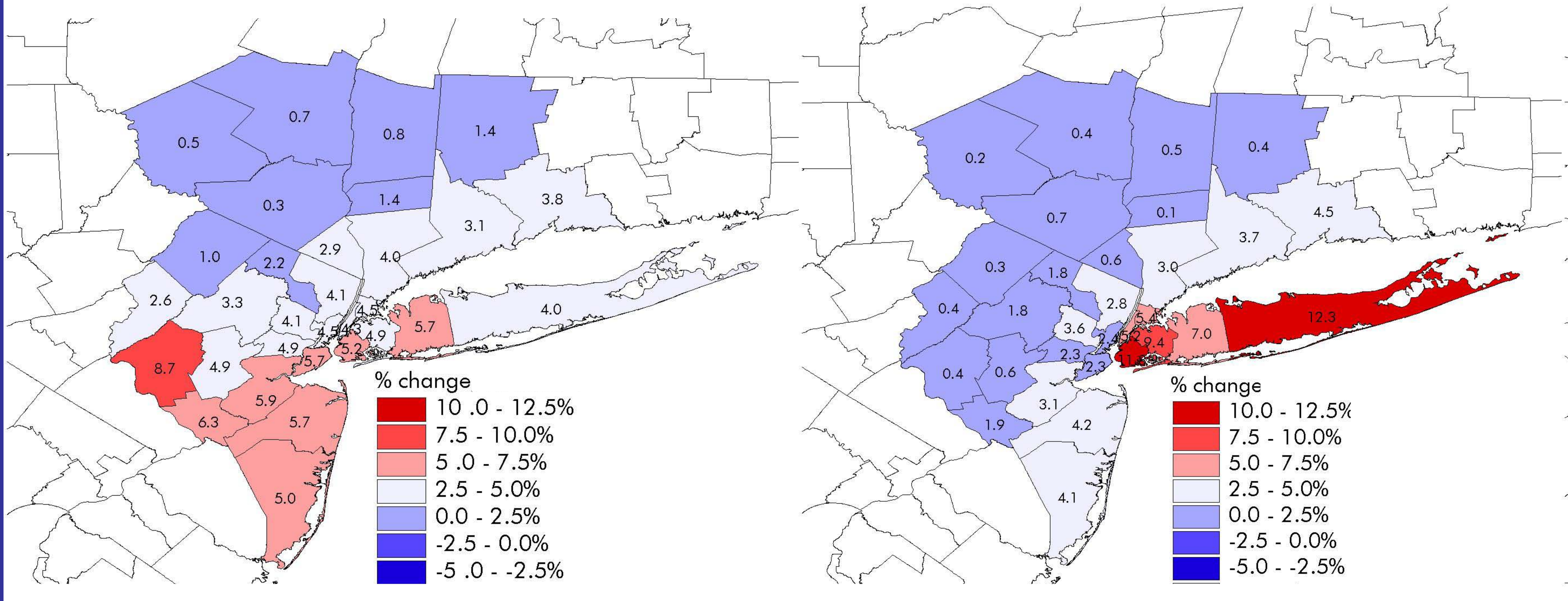
- Regional mortality projections are sensitive to climate-related change:
  - 2050s A2: +4.3% O_3-related
  - 2050s B2: +7.0% O_3-related
  - 2050s A2: -2.0% $PM_{2.5}$-related
- Population-constant assumption yields conservative mortality projections
- Results suggest need for further consideration of climate change effects on air quality in future regulatory frameworks

Future directions

- Research needed to consider feedbacks between climate change, emissions, and climate-adaptive strategies i.e., air-conditioning (Hogrefe et al., 2005a)
- NYCHP model strategy could be applied with alternative models, regions, scenarios, and health outcomes

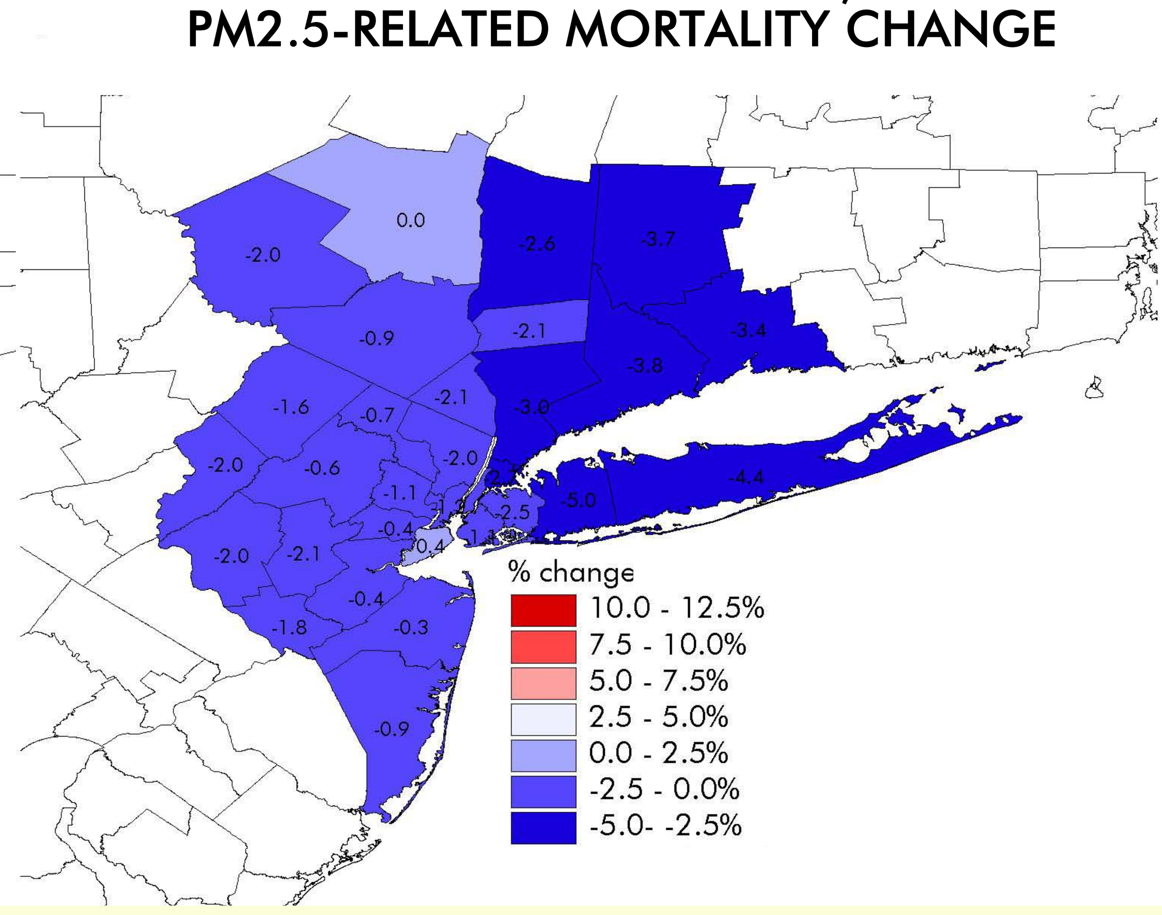
Results: Ozone- & $PM_{2.5}$-related Mortality

2050s OZONE-RELATED MORTALITY CHANGES



Summer O_3-related mortality changes, 2050s vs. 1990s:
Percent difference in 2050s A2-1990s (Left) vs. 2050s B2-1990s (Right)

A2 2050s vs. 1990s, PM2.5-RELATED MORTALITY CHANGE



References

Bell ML, Dominici F, Samet JM. 2005. *Epidemiology* (16)4:436-445.

Hogrefe C, Lynn B, Rosenzweig C, et al. October 2005. CMAS/Models-3 Workshop, October 2005.

Hogrefe C, Leung R, Mickley L, et al. 2005a. *Environmental Manager*, Air & Waste Mgmt Assoc (October 2005), 19-23.

Hogrefe C, Biswas J, Lynn B, et al. 2004. *Atmos Env* 38:2627-2638.

Hogrefe C, et al. 2004a. *J Geophys Res*109, D22301,doi:10.1029/2004JD004690.

Holloway TA, Kinney PL, Sauthoff AJ. 2005. *Energy for Sustainable Dev* 9(3):49-57.

Kinney PL, Rosenthal JE, Rosenzweig C, et al. Assessing potential public health impacts of changing climate and land use: the New York Climate and Health Project. In: Ruth M, Donaghy K, Kirshen P, eds. *Climate Change and Variability: Consequences and Responses*. Washington, D.C.: US EPA, 2005 (in press).

Knowlton K, Rosenthal J, Hogrefe C, et al. 2004. *Environ Health Perspect* 112:1557-1563.

Lynn BH, Rosenzweig C, Goldberg MS, et al. 2005 (in review). *Global and Planetary Change*.

Pope III CA, Burnett RT, Thun MJ, et al. 2002. *JAMA* 287(9):1132-1141.